

THE FLORA OF MOUNT MONADNOCK, NEW HAMPSHIRE

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Mt. Monadnock (Elevation 3,165 feet) lies in Southern New Hampshire at a distance from other hills of comparable height. This mass of granite and gneiss rising from a plain has given rise to the generic term "monadnock" for similar isolated rock peaks. The Grand Monadnock, as it is sometimes called, to distinguish it from other monadnocks, is situated in the towns of Dublin and Jaffrey. Roads surround the base of the mountain at elevations of 1,200 to 1,500 feet above sea level.

Botanically Mt. Monadnock is of interest because of the presence of a few arctic-alpine plants on the bare rocky summit area, far from other stations for them, and because of the records made by Thoreau on his four visits from 1844 to 1860, and later by other botanists, such as Stone (1885) and Deane (1890) and many later ones, some of whom deposited specimens in New England herbaria. It was my purpose to compare the present flora with that found by Thoreau.

The student of land use can read much of its history from the flora, since plant habitat is affected by what has happened to the plants. The history of Mt. Monadnock is of interest because of three distinct periods: (1) the development of complete forest cover since the time of glacial retreat, (2) its complete removal on the upper slopes by fire, and partial removal on the lower by clearing for pasture and fire, and (3) the slow renewal of vegetative cover during the last 150 years.

It is generally believed on the basis of geological and pollen evidence and observation of succession on rock and soil recently exposed by the retreat of present day glaciers, that the succession on Mt. Monadnock was probably as follows: the first pioneer plants, following lichens and mosses, may have been shrubs and forbs capable of surviving under

severe cold, wind and fluctuating moisture. These may have included species that colonize mineral soil and rock crevices, including some of the arctic-alpines. Later, as climate moderated, spruces and pines (possibly *Pinus Banksiana*) occupied the accumulations of sand and organic matter in depressions. Finally, as humus accumulated, Red Spruce (*Picea rubens*) came to dominate the flora of the upper part of the mountain where soil development was indefinitely delayed.

Mt. Monadnock was completely forested at the coming of the White Man, the summit area covered with Red Spruce to the very summit, and the lower slopes with spruce and hardwood, much as the case of lesser mountains much farther north. All similar rocky peaks below the approximately 4,500 feet climatic timberline in New Hampshire are or were completely forest-clad. Mt. Monadnock is about 1,000 feet lower than climatic timberline and lies almost 100 miles south of the nearest timberline. Tree line is higher at lower latitudes. The bare rocky summits of New Hampshire such as Chocorua, Cardigan, Firescrew, and Percy Peaks all have documented history of fire.

Until recent years there were many old stumps and logs near the summit. Thoreau wrote in his *Journal* (June 1858): "The whole rocky part of the mountain, except the extreme summit, is strewn with the relics of spruce trees a dozen or fifteen feet long, and long since dead and bleached, so that there is plenty of fuel at hand." The remains nearest the summit were no doubt first consumed by visitors campfires. Visitors were very numerous in Thoreau's day and before, and in several of his writings he reports having seen fires at the top. Since the area at the extreme summit is quite level, with depressions, it is probable that it was originally as densely forested as the rest of the mountain. Chamberlain (1936) shows a picture (p. 73) of stumps near the top. Obviously, there could not have been such severe fires at the summit had there not been timber to burn. The 1953 fire on the east slope stopped when it reached the scrub zone where there was no fuel.

There are many published reports that confirm the original forested nature of the summit. Later the practice of clearing the slopes for pasture gave rise to numerous fires.

During the celebration of the centennial of the Town of Dublin in 1852, Charles Mason made an address on June 17 (Leonard 1855) including the following remark:

“Formerly covered with trees almost to the summit.”

At the same celebration in Dublin (Leonard *op. cit.*) a letter was read from Daniel Elliott, M.D. in which he recalled: “I remember (Monadnock) when clothed with verdant foliage to the very summit.” Similar records are found in the Town of Jaffrey: “When the town was first settled the mountain was covered to its summit with forest trees, principally spruce, excepting a small peak southeast of the top, which was called the “Bald Rocks” (Cutter 1881). “Belts of heavy spruce timber on the highest portions” were reported by Child (1885). Similar references may be found in Dana (1816) and Ellis (1880).

Ecologists recognized that forest had come to occupy the mountain much as peaks farther north. Braun (1950) refers to Monadnock (p. 423) as “covered with Red Spruce from 2,300 feet upward, thus producing a small outlier of the prevailing mountain vegetation in the north.” Spurr (1964) states that “the summit of Mt. Monadnock . . . was clothed with a Red Spruce forest until destroyed by fire . . .”

Many fires have occurred during the recorded history of Mt. Monadnock, and it is possible that lightning fires may have burned in earlier times, but it is doubtful if Indians caused any fires on its forbidding slopes. In the same address referred to above (Leonard, *loc. cit.*) Charles Mason said: “A great fire spread over a great part of the superior portion of the mountain killing every tree and shrub. Dead trees falling, furnished materials for another conflagration. Some 30 years ago in the latter part of a dry summer, a fire in a clearing made its way up to the higher regions.” “Some 30 years ago” would have placed this fire about 1820, although the cause of the fire differs from other accounts given below. Also the statement of Dr. Elliott on the same

occasion: "I saw, year after year, the devouring flames climbing his lofty sides", suggests many fires.

Thoreau, on his second visit to Monadnock in 1852 (his first was in 1844, the journal report of which has not been preserved) related this incident during his passage through Peterborough: "A man in Peterborough told me that his father told him that Monadnock used to be covered with forest; that fires ran through it and killed the turf; then the trees were blown down, and their roots turned up and formed a dense and impenetrable thicket in which wolves abounded . . . till finally they set fire to this thicket and it made the greatest fire they had ever had in the county."

These and other records fail to give exact dates. As Chamberlain (1936) says (p. 97): "No documentary evidence has been found to show exactly when the fires occurred." He also quotes (p. 98) from the New Hampshire Sentinel of September 30, 1825, reporting a great fire of "some years ago". "This fire consumed only the turf. The trees turned over in every direction, and afforded about three years later fuel for a more tremendous scene." This places the two "great" fires closer together. The best evidence suggests a first fire about 1800, then the 1815 hurricane, and the final great fire in 1820. There were later ones, too. Thoreau reported ("A Walk to Wachusett", July 19, 1842) "A fire blazing on Monadnock that night, which lighted up the whole western horizon."

The first inroads of man occurred on the lower slopes that were cleared for pasture. Later, clearing progressed higher where sheep were grazed. Fire was used both for opening the areas and for keeping them so, and many of the fires that reached the upper levels both before and after the 1820 fire were caused by fire escaping from pasture burning. The repeated burning promoted the growth of blueberries, which I believe may have spread from lower pastures to the summit after the great fires. At present these are rather scarce.

Following abandonment of the pastures, these seeded into Red Spruce, and the process of reclothing the upper reaches

of the mountain progressed rapidly at first, and ever slower on the more exposed parts of the mountain. Here denudation resulted in a worsening of the climate. Wind movement increased over the bare rock, and extremes of temperature and soil moisture retarded growth. Recently a cycle of retarded spread of spruce seems to have set in, since almost no spruce trees less than forty years old can now be found on the upper part of the mountain and a high percentage of the trees display dead tops and reduction in diameter and height growth.

The large area laid bare by the fires apparently provided a favorable habitat for a few arctic-alpine plants that may have been present before the fires or had been transported from other sources. In any case they were well-established at the time of Thoreau's first visit, little over twenty years after the great fire. Those recorded by Thoreau (*Journal*, August 8, 1860, 25-28; 1670-1671) were: *Arenaria groenlandica*, *Vaccinium Vitis-Idaea* var. *minus* and *Juncus trifidus*. Others with northern or high altitude affinities, not found generally in the lowland, especially in the vicinity of Mt. Monadnock were *Potentilla tridentata* and *Smilacina trifolia*. During the present survey *Lycopodium Selago* var. *Selago* and var. *appressum* as well as *L. annotinum* var. *pungens* have been added to the list.

Thoreau limited his observations to the "upper part of the mountain," and essentially all the taxa reported by him in 1858 "within 200 feet of the summit" were also collected in 1968. Less complete were the lists of Stone (1885), Deane (1890) and Emerson (1869), probably due to the restricted area that they examined. While almost all the taxa recorded earlier are present now (at least those easily discoverable), and a substantial number of new ones have been added, there are doubtless more to be found. There have been changes in distribution and abundance of the plants recorded by the early botanists. The encroachment of Red Spruce and more especially shrubs such as *Nemopanthus mucronata*, *Rhododendron canadense* and *Kalmia angustifolia* appears to have reduced the habitat available

to the arctic-alpines. *Vaccinium Vitis-Idaea* can persist a long time under these shrubs, but fruiting is diminished. Some thirty years ago the proprietors of the Half Way House used to collect enough mountain cranberries on the mountain to supply hotel guests, while now only small quantities can be picked. This plant has almost disappeared from the southwest side where the hotel supply was largely obtained. The alpine flora seems to be increasingly restricted to the northern side of the peak where a cooler climate prevails. Further, observations indicate that there may be a successional change going on in the mats of *Vaccinium Vitis-Idaea*, that are invaded more and more by *Potentilla tridentata*. Another major change from 100 years ago is the vast reduction in *Cladonia* lichens. Thoreau remarks frequently how dense they were, crunching under foot, and dry so that fire would spread through them. *Cladonia* persists around the margins of shrubby hollows, but today does not cover extensive areas. Other lichens mentioned by Thoreau on the summit are now mostly confined to moist ravines.

Originally it was planned to limit collections to the area studied by Thoreau, "the upper part of the mountain". Because of the difficulty of determining just what this embraced, the area was extended to include land above 2,000 feet above sea level. (The Half Way House site is at 2,100 feet) Present collections have been supplemented by recent herbarium records kindly supplied by Mr. and Mrs. David E. Boufford of Keene State College. Where several collections of the same taxon were found, only the earliest record is given, in order to save space.* All records that stated Mt. Monadnock as the place of collection were included, although often the specific location was not given. Genera and species are listed in the order of Gray's Manual, 8th Edition (Fernald 1950). The following symbols are used:

(*) asterisk: reported by Thoreau 1858-1860.

(-) dash: collected 1968-1972.

*Complete lists have been deposited in several New England herbaria.

(†) dagger: collected 1968-1972, not previously reported (as far as known)

Most of the specimens collected in 1968-1972 were deposited in the University of New Hampshire and Franklin Pierce College herbaria. Abbreviations for all Herbaria consulted in this study are as follows: HNH Dartmouth College, FPC Franklin Pierce College, KSC Keene State College, NEBC New England Botanical Club, MASS University of Massachusetts, and NHA University of New Hampshire.

LIST OF THE VASCULAR FLORA OF MOUNT MONADNOCK

—*Lycopodium Selago* L. var. *Selago* L. W. Deane, Aug., 1891 (NEBC).

†—*L. Selago* L. var. *appressum* Desv. H. I. Baldwin, July, 1968 (FPC).

*—*L. lucidulum* Michx. H. I. Baldwin, Aug., 1968 (FPC, NHA).

†—*L. inundatum* L. H. I. Baldwin, Oct., 1968 (FPC).

*—*L. annotinum* L. H. D. Thoreau, Aug., 1869 (?) (NEBC).

†—*L. annotinum* L. var. *pungens* (La Pylaie) Desv. H. I. Baldwin, June, 1971 (FPC, NHA).

*—*L. clavatum* L. T. L. Steiger, Oct., 1935 (NHA).

L. clavatum L. var. *megastachyon* Fern. & Bissell, C. Jenks, Aug. 1883 (NEBC).

—*L. obscurum* L. var. *obscurum*. A. W. Driggs. Aug., 1916 (NEBC).

L. obscurum L. var. *dendroideum* (Michx.) D. C. Eat. B. L. Robinson, Aug., 1869 (NEBC).

*—*L. complanatum* L. A. W. Driggs, Aug., 1916 (NEBC).

Botrychium matricariaefolium A. Br. E. L. Rand, May, 1897 (NEBC).

†—*Osmunda cinnamomea* L. H. I. Baldwin, Aug., 1968 (FPC).

Woodsia ilvensis (L.) R. Br. B. L. Robinson, Aug., 1898 (NEBC).

—*Thelypteris Phegopteris* (L.) Slosson. E. F. Williams, June, 1894 (NEBC).

—*Dryopteris spinulosa* (O. F. Muell.) Watt. var. *americana* (Fisch.) Fernald. E. F. Williams, June, 1894 (NEBC).

- D. marginalis* (L.) Gray. *D. S. Boufford*, June, 1971 (KSC).
- †–*Polystichum acrostichoides* (Michx.) Schott. *H. I. Baldwin*, Aug., 1971 (FPC, NHA).
- *–*Dennstaedtia punctilobula* (Michx.) Moore. *H. I. Baldwin*, Oct., 1968 (FPC).
- †–*Pteridium aquilinum* (L.) Kuhn var. *latiusculum* (Desv.) Underwood. *H. I. Baldwin*, Aug., 1968 (FPC).
- *–*Polypodium virginianum* L. *W. Deane*, Aug., 1889 (HNH).
- *–*Abies balsamea* (L.) Mill., *J. R. Churchill*, May, 1895 (NEBC).
- *–*Tsuga canadensis* (L.) Carr. *H. I. Baldwin*, July, 1968 (FPC).
- *–*Picea rubens* Sarg. *E. F. Williams*, May, 1898 (HNH).
- †–*Larix laricina* (DuRoi) K. Koch. *H. I. Baldwin*, July, 1968 (FPC). (one tree at 2,900 feet on west side, two in Thoreau Bog).
- *–*Pinus Strobus* L. *A. R. Hodgdon et al.*, Aug., 1956 (NHA).
- Poa compressa* L. *W. Deane*, July, 1884 (HNH).
- P. pratensis* L. *E. F. Williams*, June, 1894 (NEBC).
- P. palustris* L. *J. R. Churchill*, July, 1890 (MASS, NEBC).
- *–*Festuca ovina* L. *E. L. Dickinson* and *F. C. Seymour*, July, 1930 (MASS).
- †–*F. rubra* L. *H. I. Baldwin*, July, 1968 (FPC).
- *–*Deschampsia flexuosa* (L.) Trin. *H. D. Thoreau*, Aug., 1860 (NEBC).
- *–*Danthonia spicata* (L.) Beauv. *H. D. Thoreau*, Aug., 1860 (NEBC).
- D. compressa* Aust. *A. S. Goodale*, July, 1927 (MASS).
- *–*Calamagrostis canadensis* (Michx.) Nutt. *H. D. Thoreau*, Aug., 1860 (NEBC).
- *–*Agrostis scabra* Willd. *H. D. Thoreau*, Aug., 1860 (NEBC).
- Scirpus atrovirens* Willd. *C. W. Jenks*, Aug., 1883 (NEBC).
- S. atrocinctus* Fern. *A. S. Goodale*, July, 1927 (MASS).
- *–*Eriophorum spissum* Fern., *H. D. Thoreau*, Aug., 1860 (?) (NEBC).
- *–*E. gracile* W. D. J. Koch. *A. S. Goodale*, July, 1927 (MASS).
- E. tenellum* Nutt. *R. M. Harper*, July, 1899 (NEBC). "3,150 feet".

- E. viridi-carinatum* (Engelm.) Fern. C. F. Batchelder, Sept., 1909 (NHA).
- E. virginicum* L. C. W. Jenks and C. W. Swan, Aug., 1883 (NEBC, NHA).
- Rhynchospora capitellata* (Michx.) Vahl. B. L. Robinson, July, 1897 (NEBC).
- †—*R. alba* (L.) Vahl. H. I. Baldwin, Oct., 1968 (FPC).
- †—*Carex stipata* Muhl. H. I. Baldwin, June, 1969 (FPC).
- **C. trisperma* Dew. H. D. Thoreau, Aug., 1860 (NEBC). "NE swamp".
- †—*C. trisperma* Dew. var. *Billingsii* Knight, H. I. Baldwin, Oct., 1968 (FPC).
- *—*C. canescens* L. "E. F. Jr." (?), 1838 (MASS).
- C. canescens* L. var. *subloliacea* Laested. Sydney Harris, June, 1894 (NEBC).
- C. brunnescens* (Pers.) Poir. W. Deane, July, 1889 (MASS).
- C. brunnescens* (Pers.) Poir. var. *sphaerostachya* (Tuckerm.) Kükenth. A. W. Driggs, Aug., 1916 (NEBC).
- C. cumulata* (Bailey) Mackenz. C. W. Jenks, Aug., 1883 (NEBC).
- C. communis* Bailey. L. Russell, 1898 (NHA).
- C. novae-angliae* Schwein. W. Deane, July, 1891 (HNH, MASS). "Mt. road below house".
- C. deflexa* Hornem. J. R. Churchill, May, 1895 (NEBC).
- C. umbellata* Schkuhr. J. R. Churchill, May, 1896 (NEBC).
- C. gracillima* Schwein. R. J. Eaton, July, 1957 (NHA).
- C. aestivalis* M. A. Curtis. J. R. Churchill, July, 1890 (MASS, NEBC).
- C. leptonervia* Fern. E. F. Williams, June, 1894 (NEBC).
- C. intumescens* Rudge. E. F. Williams, June, 1894 (NEBC).
- †—*C. nigra* L. H. I. Baldwin. July, 1971 (FPC, NHA).
- †—*Arisaema triphyllum* (L.) Schott. D. W. Allen, May, 1968 (FPC).
- Juncus bufonius* L. A. W. Driggs, Aug., 1916 (NEBC).
- *—*J. trifidus* L. C. W. Swan, Aug., 1883 (NEBC).
- J. Greenei* Oakes and Tuckerm. B. L. Robinson, Aug., 1896 (NEBC).

- J. brevicaudatus* (Engelm.) Fern. A. W. Driggs, Aug., 1916 (NEBC).
- J. articulatus* L. C. A. and A. W. Cheever, Sept., 1910 (NEBC).
- †–*Luzula multiflora* (Retz.) Lejeune. D. W. Allen, May, 1968 (FPC, NHA).
- *–*Uvularia sessilifolia* L. D. W. Allen, May, 1968 (FPC).
- *–*Clintonia borealis* (Ait.) Raf. T. L. Steiger, May, 1937 (NHA).
- †–*Smilacina racemosa* (L.) Desf. H. I. Baldwin, Sept., 1970 (FPC).
- *–*S. trifolia* (L.) Desf. Sydney Harris, June, 1894 (NEBC).
- †–*Maianthemum canadense* Desf. D. W. Allen, May, 1968 (FPC).
- Streptopus roseus* Michx. var. *perspectus* Fassett. W. Deane, July, 1889 (NEBC).
- †–*Polygonatum pubescens* (Willd.) Pursh. H. I. Baldwin, May, 1969 (FPC, NHA).
- †–*Medeola virginiana* L. D. W. Allen, May, 1968 (FPC).
- Trillium erectum* L. J. R. Churchill, May, 1883 (MASS).
- *–*T. undulatum* Willd. T. L. Steiger, May, 1937 (NHA).
- †–*Sisyrinchium montanum* Greene. H. I. Baldwin, July, 1968 (NHA).
- †–*Cypripedium acaule* Ait. D. W. Allen, May, 1968 (FPC, NHA).
- Habenaria Hookeri* Torr. Henry A. Purdie, June, 1905 (NEBC).
- Spiranthes lacera* Raf. Hodgdon and Ken Welsh, July, 1957 (NHA). “2,500 feet”.
- Malaxis uniflora* Michx. F. Hunt, Aug., 1946 (NHA).
- **Salix Bebbiana* Sarg. A. R. Hodgdon, June, 1933 (NHA).
- *–*S. discolor* Muhl. D. W. Allen, May, 1968 (FPC).
- *–*Populus tremuloides* Michx. H. I. Baldwin, Aug., 1968 (FPC).
- *–*Betula alleghaniensis* Britton. Hodgdon and Welsh, July, 1957 (NHA).
- B. populifolia* Marsh. Hodgdon et al., Aug., 1956 (NHA).
- *–*B. papyrifera* Marsh. Hattie Merrifield, July, 1879 (NEBC).

- B. papyrifera* Marsh. var. *cordifolia* (Regel) Fern. Hodgdon and Welsh, July, 1957 (NHA).
- B. papyrifera* Marsh. × *B. populifolia* Marsh. Hodgdon et al., Aug., 1956 (NHA). “2,800 feet”.
- †–*Ostrya virginiana* (Mill.) K. Koch. H. I. Baldwin, Aug., 1971 (FPC).
- Fagus grandifolia* Ehrh. Hodgdon et al., Aug., 1956 (NHA, NEBC).
- †–*Quercus rubra* L. D. W. Allen, May, 1968 (FPC).
- Polygonum aviculare* L. var. *angustissimum* Meisn. B. L. Robinson, July, 1897 (NEBC).
- **P. cilinode* Michx. W. Deane, Aug., 1889 (HNH).
- †–*P. scandens* L. H. I. Baldwin, Aug., 1972 (FPC, NHA). “one plant, Red Spot Trail”.
- †–*Claytonia caroliniana* Michx. H. I. Baldwin, June, 1971 (FPC).
- *–*Arenaria groenlandica* Du Roi. Thomas Hope, Aug., 1879 (NEBC).
- Ranunculus abortivus* L. Rand and Robinson, June, 1898 (NEBC).
- †–*R. acris* L. H. I. Baldwin, July, 1971 (NHA).
- †–*R. bulbosus* L. D. W. Allen, June, 1968 (NHA).
- †–*Thalictrum polygamum* Muhl. H. I. Baldwin, May, 1969 (NHA).
- *–*Coptis groenlandica* (Oeder) Fern. D. W. Allen, May, 1968 (FPC).
- †–*Actaea pachypoda* Ell. H. I. Baldwin, May, 1969 (FPC).
- *–*Aquilegia canadensis* L. Rand and Robinson, May, 1897 (NEBC).
- Berberis Thunbergii* DC. W. H. Manning, Oct., 1913 (NEBC).
- Drosera intermedia* Hayne. Fred M. Hunt, Aug., 1946 (NHA).
- †–*D. rotundifolia* L. H. I. Baldwin, July, 1968 (FPC, NHA).
- †–*Chrysosplenium americanum* Schwein. D. E. Boufford, 1971 (KSC).
- **Ribes cynosbati* L. T. Otis Fuller, June, 1883 (NEBC).
- *–*R. glandulosum* Grauer. J. R. Churchill, May, 1883 (NHA).

- R. triste* Pall. T. L. Steiger, May, 1937 (NHA).
- *—*Spiraea latifolia* (Ait.) Borkh. A. W. Driggs, Aug., 1916 (NEBC). "above timberline".
- †—*S. tomentosa* L. H. I. Baldwin, July, 1968 (FPC).
- *—*Pyrus melanocarpa* (Michx.) Willd. C. F. Batchelder, Sept., 1909 (NHA).
- *—*P. americana* (Marsh.) DC. J. R. Churchill, July, 1890 (HNH).
- P. decora* (Sarg.) Hyland. Hodgdon and Kenneth Welsh, July, 1957 (NEBC). "2,500 feet".
- P. americana* L. × *P. decora* (Sarg.) Hyland. Hodgdon and Kenneth Welsh, July, 1957 (NEBC). "2,500 feet".
- *—*Amelanchier laevis* Wieg. Rand and Robinson, May, 1897 (NEBC).
- *—*A. Bartramiana* (Tausch.) Roemer. J. R. Churchill, May, 1885 (NEBC).
- A. Bartramiana* (Tausch.) Roemer. × *A. neglecta* (?) Rand and Robinson, May, 1897 (NEBC).
- †—*Crataegus macrosperma* Ashe. D. W. Allen, May, 1968 (NHA).
- †—*Fragaria virginiana* Duchesne. D. W. Allen, May, 1968 (FPC).
- Potentilla fruticosa* L. J. A. Bates, Aug., 1900 (NEBC).
- *—*P. tridentata* Ait. E. S. Hoar, July, 1857 (NEBC).
- P. norwegica* L. A. W. Driggs, Aug., 1916 (NEBC). "summit".
- †—*P. canadensis* L. H. I. Baldwin, June, 1969 (FPC, NHA).
- †—*P. simplex* Michx. H. I. Baldwin, May, 1970 (FPC).
- Geum aleppicum* Jacq. var. *strictum* (Ait.) Fern. Henry Purdie, July, 1905 (HNH).
- Rubus hispidus* L. J. P. Poole, July, 1939 (HNH, NHA).
- R. setosus* Bigel. A. W. Driggs, Aug., 1916 (NEBC).
- *—*R. vermontanus* Blanch. B. L. Robinson, July, 1897 (NEBC).
- R. allegheniensis* Porter. A. W. Driggs, Aug., 1916 (NEBC).
- †—*R. frondosus* Bigel. H. I. Baldwin, July, 1968 (FPC).
- *—*Prunus pensylvanica* L. f. C. W. Jenks, Aug., 1883 (NEBC).
- †—*P. serotina* Ehrh. H. I. Baldwin, July, 1968 (FPC).
- †—*Trifolium repens* L. D. W. Allen, June, 1968 (FPC).

- Oxalis montana* Raf. T. Otis Fuller, June, 1883 (NHA).
- Polygala sanguinea* L. R. H. Piper, July, 1927 (MASS).
- *—*Nemopanthus mucronata* (L.) Trel. Rand and Robinson, May, 1897 (NEBC).
- *—*Acer spicatum* Lam. Sydney Harris, June, 1894 (NEBC).
- *—*A. pensylvanicum* L. C. W. Jenks, Aug., 1883 (NEBC).
- †—*A. saccharum* Marsh. H. I. Baldwin, June, 1968 (FPC).
- *—*A. rubrum* L. H. I. Baldwin, June, 1968 (FPC, NHA).
- Hypericum perforatum* L. J. P. Poole, July, 1939 (HNH).
- H. canadense* L. Mary E. Gilbreth, Aug., 1889 (NEBC).
(one extremely small plant found in 1971, H. I. Baldwin)
- †—*Viola papilionacea* Pursh. H. I. Baldwin, May, 1969 (NHA).
- V. sororia* Willd. E. F. Williams, May, 1898 (NEBC).
- V. fimbriatula* Sm. E. F. Williams, May, 1898 (NEBC).
- V. pallens* (Banks) Brainerd. A. W. Cheever, Sept., 1910 (HNH).
- V. blanda* Willd. J. R. Churchill, July, 1890 (HNH, NEBC).
- V. lanceolata* L. A. R. Hodgdon, June, 1933 (NHA).
- †—*V. rotundifolia* Michx. H. I. Baldwin, April, 1969 (NHA).
- V. adunca* Sm. Rand and Robinson, May, 1897 (NEBC).
- †—*V. conspersa* Reichenb. H. I. Baldwin, May, 1971 (FPC).
- Circaea alpina* L. Edward S. Hoar, 1879 (NEBC).
- *—*Epilobium angustifolium* L. H. I. Baldwin, Aug., 1971 (FPC).
- E. leptophyllum* Raf. C. W. Jenks, Aug., 1883 (NEBC).
- Aralia racemosa* L. Hattie Merrifield, July, 1879 (NEBC).
- *—*A. hispida* Vent. J. P. Poole, July, 1939 (HNH, NHA).
- A. nudicaulis* L. A. S. Goodale, May, 1926 (MASS).
- †—*Panax trifolius* L. D. W. Allen, May, 1968 (FPC, NHA).
- *—*Cornus canadensis* L. C. W. Jenks, Aug., 1883 (NEBC).
- C. alternifolia* L. f. Hodgdon et al., Aug., 1956 (NHA).
- Chimaphila umbellata* (L.) Bart. var. *cisatlantica* Blake. J. P. Poole, July, 1939, (HNH, NHA).
- †—*Monotropa uniflora* L. H. I. Baldwin, Sept., 1968 (FPC).
(rare).
- *—*Ledum groenlandicum* Oeder. Sydney Harris, June, 1894 (NEBC).

- *-*Rhododendron canadense* (L.) Torr. Sydney Harris, June, 1883 (NEBC).
- *-*Kalmia angustifolia* L. J. P. Poole, July, 1939 (HNH).
- †-*Cassandra calyculata* (L.) D. Don. D. W. Allen, May, 1968 (FPC).
- *-*Epigaea repens* L. H. I. Baldwin, April, 1969 (FPC).
“(one plant only, on cliff).”
- **Gaultheria hispidula* (L.) Bigel. C. G. Trow, 1871 (MASS).
- †-*Calluna vulgaris* (L.) Hull. H. I. Baldwin, May, 1965 (NHA). (one isolated colony (introd)).
- Gaylussacia baccata* (Wand.) K. Koch. A. W. Driggs, Aug., 1916 (NEBC).
- Vaccinium myrtilloides* Michx. Hodgdon et al., Aug., 1956 (NHA). “2,800 feet”.
- *-*V. angustifolium* Ait. W. Deane, Aug., 1889 (HNH).
- V. angustifolium* Ait. var. *laevifolium* House. B. L. Robinson, July, 1897 (NEBC).
- †-*V. angustifolium* Ait. × *V. corymbosum* L. H. I. Baldwin, Aug., 1969 (NHA).
- V. angustifolium* Ait. var. *nigrum* (Wood) Dole. Fred M. Hunt, Aug., 1946 (NHA).
- V. corymbosum* L. A. S. Goodale, May, 1926 (MASS).
- *-*V. Vitis-Idaea* L. var. *minus* Lodd. C. G. Trow, Aug., 1864 (MASS).
- †-*Asclepias syriaca* L. H. I. Baldwin, July, 1971 (FPC).
- *-*Trientalis borealis* Raf. D. W. Allen, May, 1968 (FPC).
- Lysimachia terrestris* (L.) BSP. J. P. Poole, July, 1939 (HNH, NHA).
- †-*Fraxinus americana* L. H. I. Baldwin, July, 1968 (FPC).
- Hedeoma pulegioides* (L.) Pers. B. L. Robinson, Aug., 1896 (NEBC).
- †-*Veronica longifolia* L. Hodgdon and Hehre, Aug., 1969 (NHA).
- †-*V. officinalis* L. H. I. Baldwin, June, 1969 (FPC, NHA).
- Gerardia tenuifolia* Vahl. B. L. Robinson, Aug., 1898 (NEBC).
- *-*Melampyrum lineare* Desr. var. *americanum* (Michx.) Beauv. D. W. Allen, June, 1968 (FPC).

- †—*Mitchella repens* L. H. I. Baldwin, Aug., 1968 (FPC, NHA).
rare.
- †—*Houstonia caerulea* L. D. W. Allen, May, 1968 (FPC, NHA).
- *—*Diervilla Lonicera* Mill. C. W. Jenks, Aug., 1883 (NEBC).
- *—*Viburnum alnifolium* Marsh. C. W. Jenks, Aug., 1883 (NEBC).
- *—*V. cassinoides* L. C. L. Canfield, June, 1931 (NHA).
- *—*Sambucus pubens* Michx. W. Deane, July, 1891 (NEBC).
- †—*Solidago caesia* L. H. I. Baldwin, Sept., 1970 (FPC).
- *—*S. macrophylla* Pursh. W. Deane, Aug. 1891 (HNH, NHA, MASS).
- S. puberula* Nutt. Mary E. Gilbreth, Aug., 1889 (NEBC).
- S. Randii* (Porter) Britt. C. W. Jenks, Aug., 1883 (NHA).
- S. Randii* (Porter) Britt. var. *monticola* Porter. C. F. Batchelder, June, 1919 (NHA).
- S. juncea* Ait. Parsons and Seymour, Aug., 1927 (MASS).
- S. nemoralis* Ait. Fred M. Hunt, Aug., 1945 (NHA).
- *—*S. rugosa* Ait. var. *rugosa* H. I. Baldwin, Oct., 1968 (NHA).
- *—*S. graminifolia* (L.) Salisb. H. I. Baldwin, Sept., 1968 (FPC, NHA).
- †—*Aster divaricatus* L. H. I. Baldwin, Sept., 1968 (FPC).
- *—*A. acuminatus* Michx. B. L. Robinson, Aug., 1896 (NEBC).
- †—*Erigeron pulchellus* Michx. H. I. Baldwin, July, 1968 (FPC).
- *—*Anaphalis margaritacea* (L.) B.&H. D. W. Allen, May, 1968 (FPC).
- Gnaphalium Macounii* Greene. C. W. Jenks, Aug., 1883 (NHA).
- G. obtusifolium* L. C. A. Cheever, Sept., 1910 (HNH).
- G. uliginosum* L. W. Deane, Aug. 1891 (HNH).
- *—*Achillea Millefolium* L. D. W. Allen, May, 1968 (FPC).
- †—*Chrysanthemum Leucanthemum* L. var. *pinnatifidum* Lecoq and Lamotte. H. I. Baldwin, July, 1971 (FPC, NHA).
- Taraxacum erythrospermum* Andrzej. E. F. Williams, May, 1898 (HNH).
- T. officinale* Weber. E. F. Williams, May, 1898 (NEBC).
- †—*Prenanthes trifoliata* (Cass.) Fern. var. *nana* (Bigel.) Fern. D. W. Allen, May, 1968 (FPC).
- †—*P. altissima* L. H. I. Baldwin, Aug., 1968 (NHA).

Additional taxa reported by Thoreau in his journals of 1858 and 1860. The names, as given by Thoreau, including his question marks are at the left in the following list: Contemporary accepted binomials are listed at the right opposite the name he used if that name is no longer used or if only a common name were given by him.

Sensitive fern	<i>Onoclea sensibilis</i> L.
Black spruce	No <i>Picea mariana</i> (Mill) BSP. has been found since Thoreau's visits; this may be <i>P. rubens</i> Sarg.
<i>Cinna arundinacea</i>	
<i>Glyceria elongata</i>	<i>G. melicaria</i> (Michx.) F. T. Hubbard
<i>Eleocharis tenuis</i>	
<i>Scirpus Eriophorum</i>	<i>S. cyperinus</i> (L.) Kunth.
<i>Carex straminea</i>	<i>C. tenera</i> Desv.
<i>C. scoparia</i> ?	
<i>C. debilis</i>	
<i>C. Deweyana</i>	
<i>Juncus acuminatus</i> ?	<i>J. acuminatus</i> Michx. or <i>J. canadensis</i> J. Gay
<i>J. paradoxus</i> ?	perhaps <i>J. canadensis</i> or <i>J. acuminatus</i>
<i>Salix lucida</i>	
<i>S. humilis</i>	
<i>Tiarella cordifolia</i>	
<i>Amelanchier canadensis</i>	
var <i>Botryapium</i>	<i>A. arborea</i> (Michx. F.) Fern.
<i>A. canadensis</i>	
var <i>oblongifolia</i>	<i>A. canadensis</i> (L.) Medic.
<i>Geranium Robertianum</i>	
<i>Epilobium palustre</i>	
Water andromeda	<i>A. glaucophylla</i> Link or <i>Kalmia polifolia</i> Wang.
Checkerberry	<i>Gaultheria procumbens</i> L.
<i>Chelone glabra</i>	
<i>Solidago virgaurea</i>	?

Three-ribbed goldenrod

(not *canadensis*)

S. altissima L. or *S. gigantea* Ait.

Aster thyrsoides

?

Diplopappus umbellatus

Aster umbellatus Mill.

DISCUSSION

The present flora of the upper part of Mt. Monadnock is as noteworthy for the absence of certain plants as by the presence of unusual ones such as the arctic-alpines. Thus *Alnus* has not been found anywhere on the slopes of the mountain, nor has *Picea mariana* been recorded from the spruce-lined bogs. *Acer saccharum* is confined to a small area on the east side. Further there are many instances of lowland adventives that take root and may thrive for a time and then disappear. This may explain why some species recorded earlier have not now been found (aside from less keen observation). A total of 220 taxa are represented by specimens in herbaria, including 152 taxa collected from 1965 to 1972. Fifty-nine taxa collected during this period were not previously found in herbaria, and may possibly have been collected for the first time on the mountain. Of the 94 taxa reported by Thoreau, 68 of which are in herbaria, 62 were collected during the present survey.

Thoreau observed seeds of many lowland plants blowing over the summit, and reflected on the origin of adventives (and perhaps transitory taxa) :

"I saw what I took to be a thistle-down going low over the summit, and might have caught it, though I saw no thistle on the mountain top, nor any other plant from which this could have come. (I have no doubt it was a thistle by its appearance and its season.) It had evidently come up from the country below. This shows that it may carry its seeds to higher regions than it inhabits, and it suggests how the seeds of some mountain plants, such as the *Solidago thyrsoides* may be conveyed from mountain to mountain, also other solidagos, asters, epilobiums, willows, etc." Thoreau: *Journal* August 9, 1860, (p. 50) (page 1677 in the 1962 Dover edition).

It seems obvious that most of the wind-disseminated species that have restocked the mountain since the 1820 fire, including Red Spruce, have come by the aerial route, mostly probably from the adjacent lowland. Light-seeded arctic-alpines may be included. It is less easy to explain how heavy-seeded plants such as *Vaccinium* arrived. These may have been present before the fires, surviving the shade of spruce on some steep ledges, or they may have been carried by birds migrating from timberline areas in the White Mountains.

According to Pease (1964 p. 15) the following taxa collected or reported from Mt. Monadnock "may be listed as essentially alpine":

Lycopodium Selago (including *var. appressum*)

Lycopodium annotinum var. pungens

Juncus trifidus

Arenaria groenlandica

Solidago macrophylla var. thyrsoides

Mt. Monadnock appears to be the southern limit for some of these.

The relation of fire to the occurrence of arctic-alpine plants needs more investigation. It is curious that they became so abundant on Mt. Monadnock 29-30 years after the great fire. Do the ashes from fire favor their establishment (Fernald (1907) thought alkaline soil most *unfavorable*) or is it open space, exposed rock crevices, or mineral soil alone? Many years ago, searching for *Vaccinium Vitis-Idaea* on Cape Breton, I could find it only on an area that had been swept by fire about ten years before.

There are thus at least two possible explanations for the presence on Mt. Monadnock of taxa usually found above timberline:

(1) They have survived since post-glacial times in refugia on the mountain itself possibly on lower slopes as proposed by Fernald (1907, 1925), and then survived the fires (which were very severe indeed), and then restocked the bare rock and open soil.

(2) The summit flora may have arisen from disseminules

carried from timberline areas by wind, animals or birds, or even men.

Steele and Hodgdon (1973) reached the same possible explanations for the presence of *Carex capitata* and *Carex Bigelowii* on Mt. Cardigan.

Regardless of the origin of the present flora, processes of change are at work, reducing the abundance and area occupied by some plants, while others are assuming dominance. Many lowland forms may invade and thrive for a time and then disappear. Neither the rate nor direction of succession is uniform. Invasion of spruce on the upper rocks has slowed to a temporary halt, even while the extent of arctic-alpine plants declines.

The Problem of the Source and Persistence of Arctic-Alpine Plants

How did arctic-alpine plants survive from post-glacial times on lower mountains and escape competition with the forest?

One explanation for the presence of arctic-alpine plants below timberline is that they survived in refugia, rock crevices or small exposed ledges since post-glacial times, and that these crevices and ledges did not become overgrown by other plants and that the microclimate remained favorable. Then, when more open habitat was exposed by fire, these plants re-invaded the bare summits and increased greatly. Fernald (1907) postulated that alpine plants, "forced to find temporary homes during the ice age on potassic, calcareous or magnesium areas, found in the alluvial deposits a mixed soil in which they were able to spread. As climate at low altitudes became warmer, these plants found on cold cliffs and exposed mountain summits the only habitats in which they have been able to persist within the temperate regions" It is fairly easy to understand that they were able to persist on alpine tundra above timberline, and indeed on some "cold cliffs" like those in Dixville Notch, New Hampshire, and possibly elsewhere. Some plants usually restricted to high altitudes and open tundra habitats

are occasionally found below timberline, e.g. on talus and rock piles in Carter Notch (a cool place) and even in some open pastures (where they may be rather temporary residents). They cannot tolerate shade or root competition of lowland plants. A small colony of Mountain Cranberry is found along the Half Way House road on Monadnock (possibly introduced from the summit by berry pickers).

However, most steep rocky mountains that, like Monadnock, do not reach timberline and have not been burned recently, are densely forested with spruce and at higher levels, fir, with a heavy ground cover of moss, ferns and herbs. There are probably hundreds of such mountains in the Adirondacks and New England. Some of them have exposed rocky cliffs, but records showing these to be havens for alpine plants in undisturbed condition are few or wanting. Pease (*op. cit.*) reported finding some arctic-alpines on open ledges on secondary mountains in the White Mountains, "often caused by the destruction of the peaty humus by fires," but he did not specify just how often these cases were, nor did he give examples of such cases where there was no trace or history of fire. He ventured no theory as to how these plants reached the lowland habitat.

If arctic-alpine plants persisted in refugia in lower mountains after the latter became forest-covered, it should be possible to find these plants on unburned summits. They have not been found, aside from the cases cited by Pease, which were all close to high mountains supporting stable colonies of these plants, whence invasion of even small burned areas would be relatively easy compared to Mt. Monadnock, which is far more remote.

More examples of bona fide refugia from ice-age times need to be found, but even if these can be discovered and dated, it may be impossible to demonstrate that no fires occurred very long ago, or to prove how long the plants have been on the site. Arctic flora of the Pleistocene became adapted to the prevailing habitat conditions (Cf. Fernald, 1925) and it is still largely restricted to areas of open ground and a cool, moist climate.

Did Arctic-alpine Plants Survive Fire and Spread Over the Denuded Areas?

Assuming that these plants had succeeded in resisting the competition of shade-tolerant trees and other plants, and had remained in some secluded pocket since post-glacial times, did they then survive the very intense fires that burned these peaks, more destructive than any fires in modern times? Fire destroyed all organic matter, and what little mineral soil remained was then at the mercy of wind and water. It must be remembered that two great fires on Monadnock combined to make a tremendously hot and extensive burn. The 1800 fire consumed the humus and killed the trees. The 1815 hurricane completed toppling them, so that a formidable quantity of dry fuel was present. (It was after a long hot, dry summer.) No fires in recent times have approached it in heat and ferocity. Emerson (1896) remarked that the heat was so great that it "blasted the rock" into the ravines and caused slides.

How did Arctic-alpine Plants Come to Occupy Areas Denuded by Fire?

Such plants must have arisen from disseminules brought from nearby areas (refugia on the same mountain or in the lowland) or from more distant sources, probably stretches of alpine tundra on Mt. Moosilauke or on the Presidential Range. Since the lowland and lower slopes around Monadnock were largely cleared and cultivated or pastured, it is possible that some of these plants had escaped from rocky crevices on the mountain before the fire and had become established on the lower open land. Here they might maintain themselves until forest succession once more eliminated them. At the time of the fire, this land was still open. Even if restocking of the burned mountain had proceeded from this source, it is hard to see how the spread of heavy-seeded species could have occurred uphill without the aid of birds or animals. The latter carry seeds in burs that cling to animal fur, but animals have not been found to be effective carriers of berries and similar hard seeds.

Were Birds Partly Responsible for the Spread of Plants
From Alpine Tundra to Monadnock?

Birds are well-known to be active and efficient carriers of seeds. Ridley (1930) noted that birds are attracted by seed color. Red seems to be the most attractive. *Vaccinium* is a "bird-dispersed genus", he wrote. Forty-three species of birds have been recorded to disperse plants of this genus, and it seems likely that the red fruit of Mountain Cranberry would be very much sought by birds. Taylor (1954) suggested that birds are probably responsible for carrying seeds to Macquarie Island, a small sub-antarctic island far from any large land area that was severely glaciated during the Pleistocene. He believed it unlikely that any of the 35 plant species could have survived the ice. Most of these have relatively large seeds, but all have propagules suited to bird transport.

Birds are important agents in the natural dissemination of seeds of tree species having fleshy fruits, and presumably shrubs as well. Red Cedar, Black Cherry and Black Gum are examples. Seeds of *Juniperus* that have been eaten by birds are said to germinate more promptly. (Anon. 1948) Indeed such hard-seeded species that display seed coat dormancy may require the acid treatment received during passage through a bird's intestinal tract in order to germinate. Phillips (1910) made an especially thorough and wide-ranging study of bird dissemination of *Juniperus* seed, and concluded that birds are responsible for most of the spread of junipers, especially upwards on slopes and up stream courses.

It is possible that the most likely candidate for being a vector of seeds from alpine fell fields is the Slate-Colored Junco. Not only did Thoreau remark about its being the most common bird on Monadnock, but it is also abundant there today. Forbush (1929) states that it is probably the only bird that nests above tree limit in the White Mountains. (I have found a nest with eggs in late June on Boott Spur.) Forbush (*op. cit.* p. 90) reported that it eats many

dried berries and seeds. Objections to the theory of bird transport include the questions concerning birds eating before migration, seeds passing undamaged, and limits set by the time to pass through the digestive tract. Egler (1972) questions the explanation "by having far-flying constipated birds eject over distant lands."

While there is thus evidence that some birds do carry seeds, and birds are present on Mt. Monadnock, and that seeds survive the treatment, or may be even benefited by it, it is still not proven that heavy-seeded arctic-alpine plants did actually become established on Monadnock by this means.

Since this was written, Steele and Hodgdon (1973) have examined these theories for the arrival on Mt. Cardigan of two alpine species of *Carex*. They suggest a third possibility, that man may have consciously or unconsciously introduced these plants to the bare rocky area. This appears least likely in the case of the plants found on Monadnock, because of the distance. It is also improbable that these plants should appear on Mt. Chocorua and other sites. It would be a very diligent Johnny Appleseed indeed. More important, a prolonged period must be assumed for establishment. Success probably did not come with the first seed.

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